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Measurements of Cluster Ions Using a Nano Radial DMA and a Particle Size Magnifier in CLOUD

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Abstract. We built a new instrumental setup for measuring ion distributions in the size range [1.3 - 6] nm. The implementation of an high transmission inlet increased the total transmission efficiency to more than 6% at 1.47 nm mobility equivalent diameter, allowing the detection of ions at atmospheric concentrations. The size resolution of our measurements is as high as 6. We characterized the instrument in the laboratory and carried out measurements during the CLOUD7 campaign. We compared the results obtained with the Neutral cluster and Air Ion spectrometer finding very good agreement.

Keywords: Ions, nano radial DMA, CLOUD experiment
PACS: 92.60.Mt

INTRODUCTION

Measuring ambient ions at high size resolution is very important to understand many aspects of the atmosphere of our planet. Ions are responsible for changing the conductivity of the air, influencing the global electric circuit [2].

They are also important for the climate of our planet via the production of secondary aerosol. It is known that ions and aerosol particle formation are related, however the details about how much ions can enhance atmospheric aerosol production in our planet is still under debate [3, 4].

Measuring atmospheric ions is challenging because we want to maximize the size resolution, keep the transmission efficiency high enough for measuring ambient concentrations and have a quantitative measurement of their concentrations. Measuring atmospheric ions is also the first step towards measuring neutral clusters and aerosol nano particles, once assessed which charging mechanism is more suitable for our purpose, especially in the sub 3 nm size range. An instrument that measures ion size distributions at high size resolution would be complementary to the present commercial instrumentation e.g. Air Ion Spectrometer (AIS) [5] and Atmospheric Pressure interface Time of Flight Mass Spectrometer (APi-TOF) [6], adding valuable information about the link between formation and growth of atmospheric cluster ions.

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In this work we present a new instrumental setup that allows the detection of ions in the size range from 1.3 to 6 nm at a size resolution of about 6. Our setup is able to detect ions at concentrations comparable to the ones found in ambient.

INSTRUMENTS AND METHODS

The instrumental setup used for measuring ion size distributions consists of a nano Radial DMA (nRDMA) [7] equipped with a new high transmission inlet and a Particle Size Magnifier (PSM, Airmodus 09) [8] used as a counter.

We characterized the nRDMA and the new high transmission inlet carrying out a set of experiments in the laboratory, in order to determine the transmission efficiency and its transfer functions using mobility standards and ammonium sulfate (Figure 1). We also determined its resolving power.

We also carried out measurement at the CLOUD chamber at CERN during the CLOUD7 campaign, using the new setup equipped with a cooling system for the sheath air to keep it at the same temperature as the chamber (5 ^{o}C) to avoid evaporation of the sample in the DMA

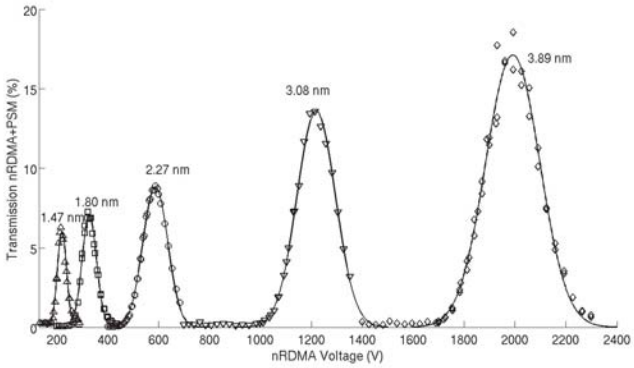

FIGURE 1. Measured transfer functions of the nRDMA, at the top of each gaussian peak is indicated the mobility equivalent diameter of the monodisperse test aerosol used for the determination of the transfer function.

RESULTS AND CONCLUSION

We built and tested a new instrumental setup consisting of a PSM, a nRDMA and new high transmission inlet. The implementation of the high transmission inlet was essential to be able to measure concentrations of a few hundred ions per cc distributed in the size range [1.3 - 6] nm, allowing measurements of ions at ambient concentrations in the future. We determined the transfer functions, the transmission efficiency and the size resolution of this setup. We measured ion size distributions in the CLOUD7 campaign and we are going to measure in Hyytiälä during the spring campaign 2013 and compare the results. We are going to present a comparison of the observations obtained using this setup and the NAIS measurements in ion mode (Figure 2).

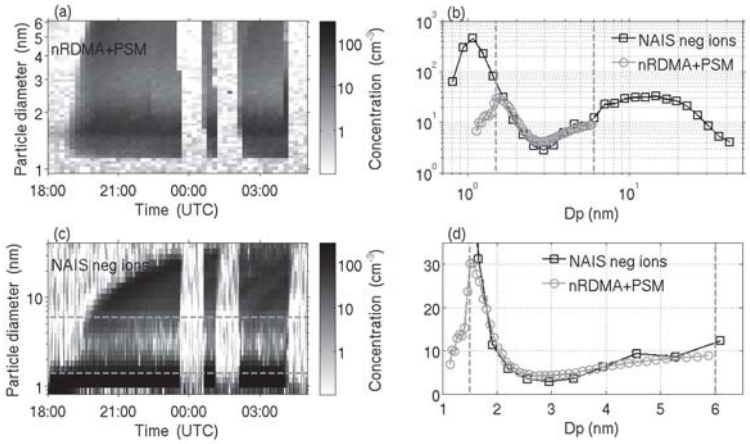

FIGURE 2. In panel (a) and (c) is shown a comparison between our setup and NAIS ion mode during the CLOUD7 campaign, note that where the concentration is dropping abruptly (at 00:00 and at 01:00 UTC) an electric field inside the chamber was turned on and the ions were swept away. In panel (c) the horizontal dashed lines delimit the size range overlapping with the size range measured using the nRDMA and PSM setup. In panel b. is shown the corresponding number size distribution for the same time interval as in panel (a) and (c), in panel (d) is shown a detail of the number size distribution of panel (b) plotted in linear scale.

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